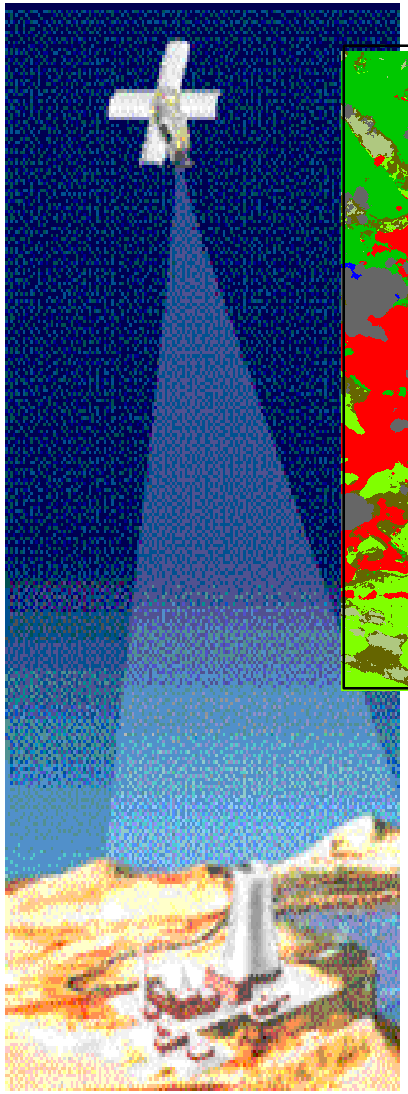
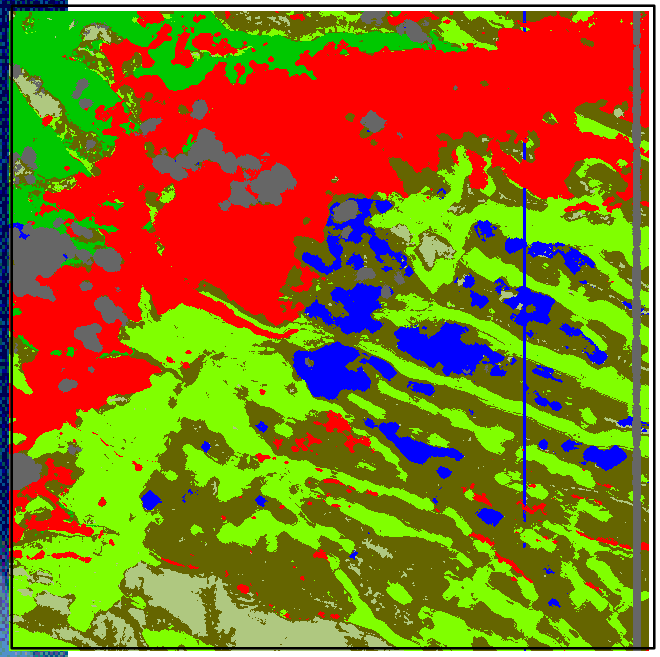
Rapid Feature Identification Project



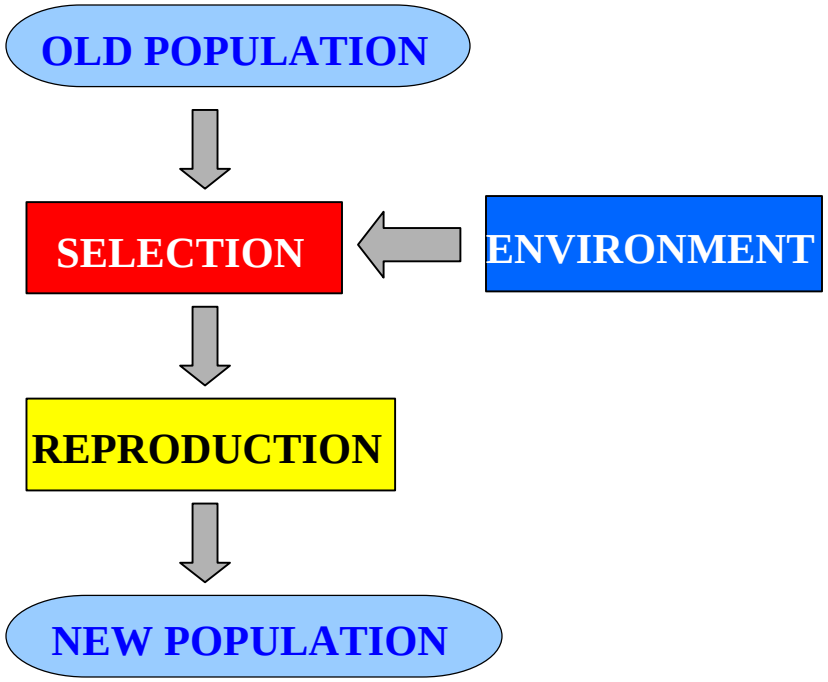


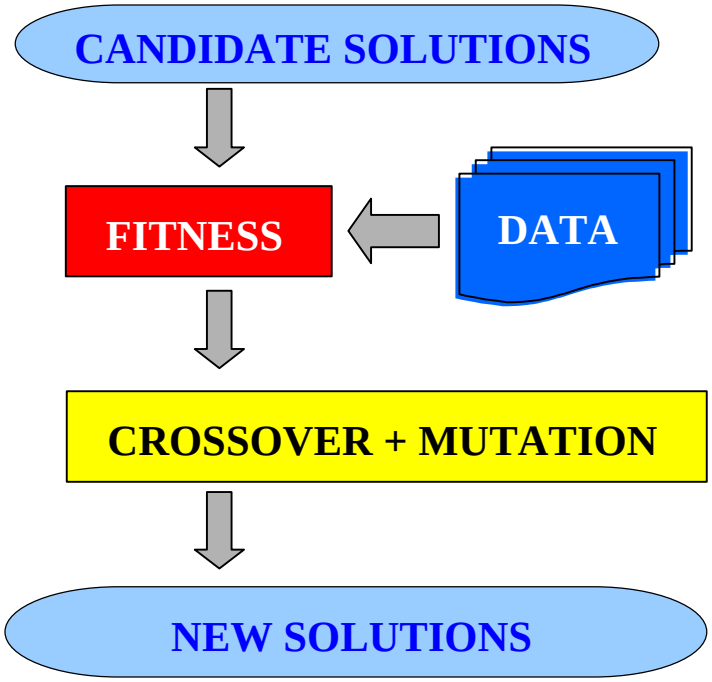
- Adaptive Algorithms for Multispectral Imagery
- Automated Evolution of New Image Analysis Tools
  - Allows Expert Assistance
  - Incorporates Existing Tools
  - Uses Spatio-Spectral info
  - Exploits Fused Data
- "Rapid Feature" Identification
- Land Cover Classification
- Change Detection

http:/www.daps.lanl.gov/genie

- *Intuitive User Interface*
- *Parallel/Scalable Implementation*
- *RCC Hardware Acceleration*

Evolution and the Genetic Algorithm

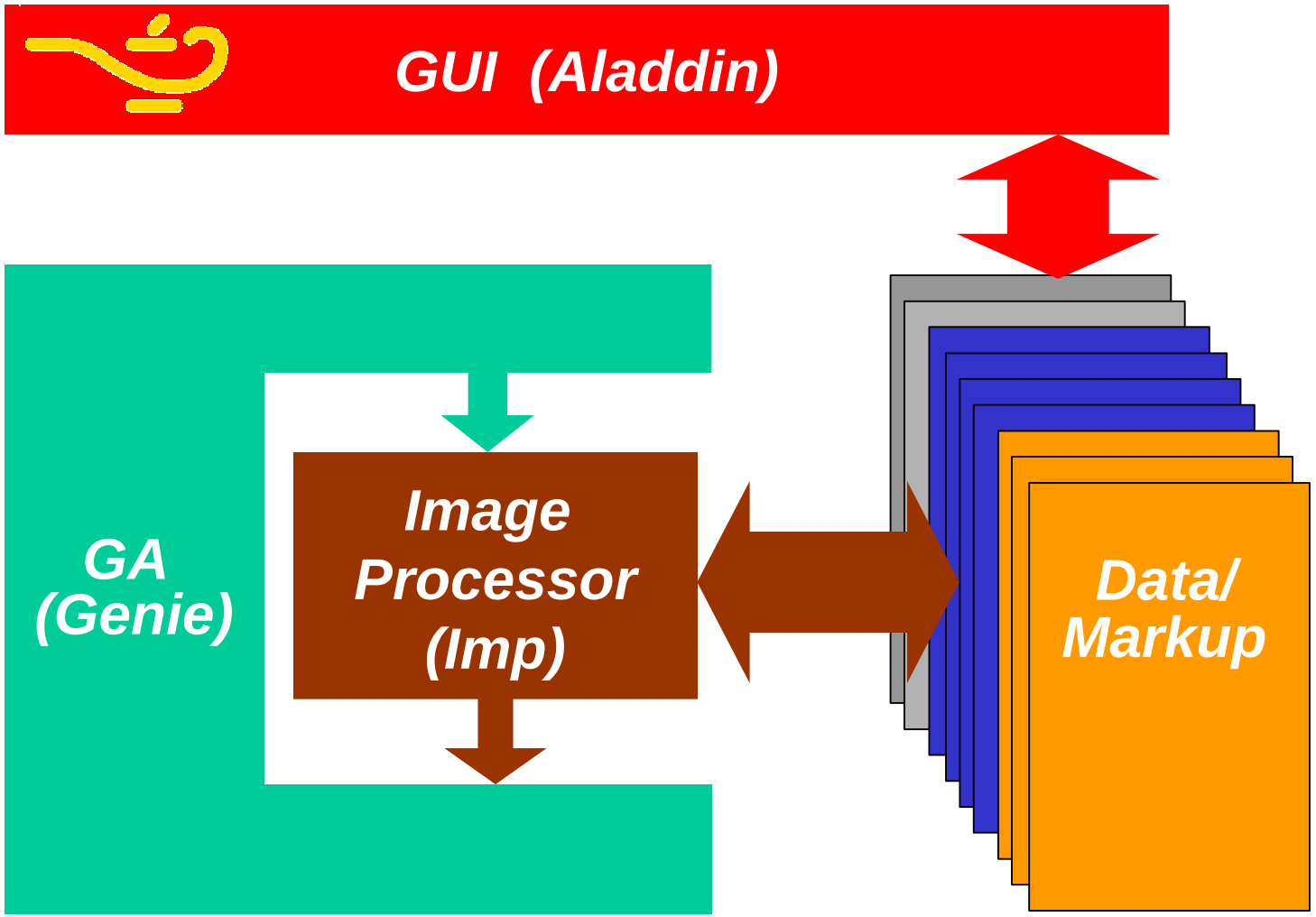




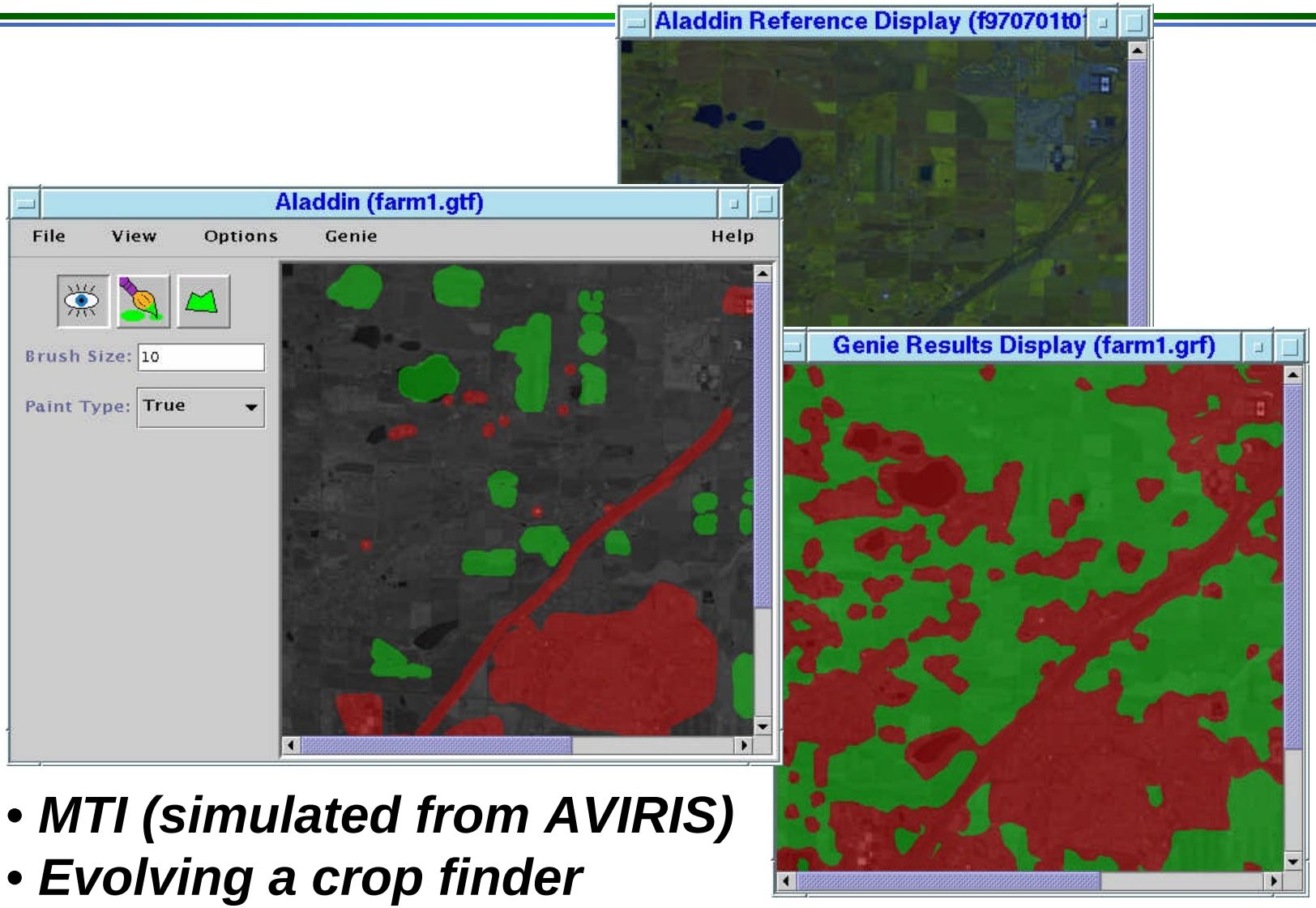
A population evolves in response to the environment in which the fittest individuals survive.

The fittest solutions are those that produce results most consistent with the training data.

Software Architecture

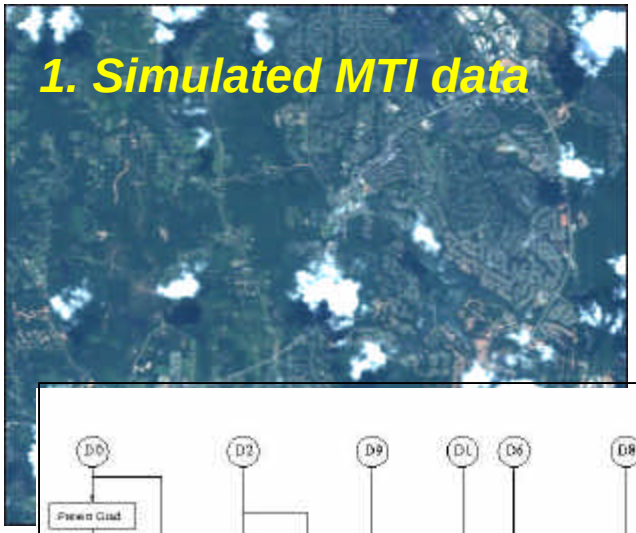


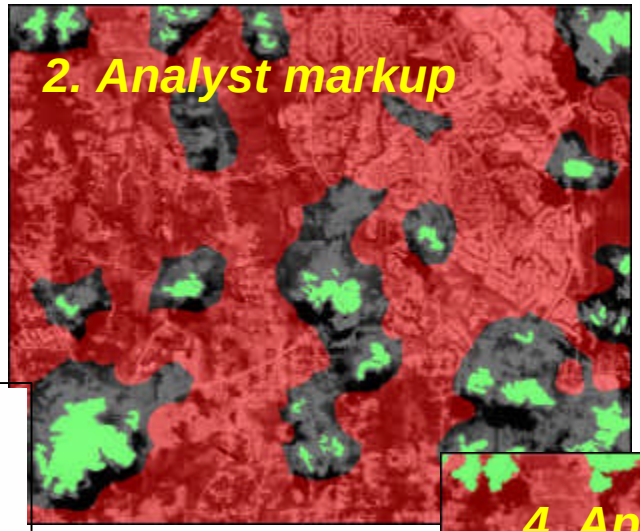
Point-and-Click Training using Aladdin

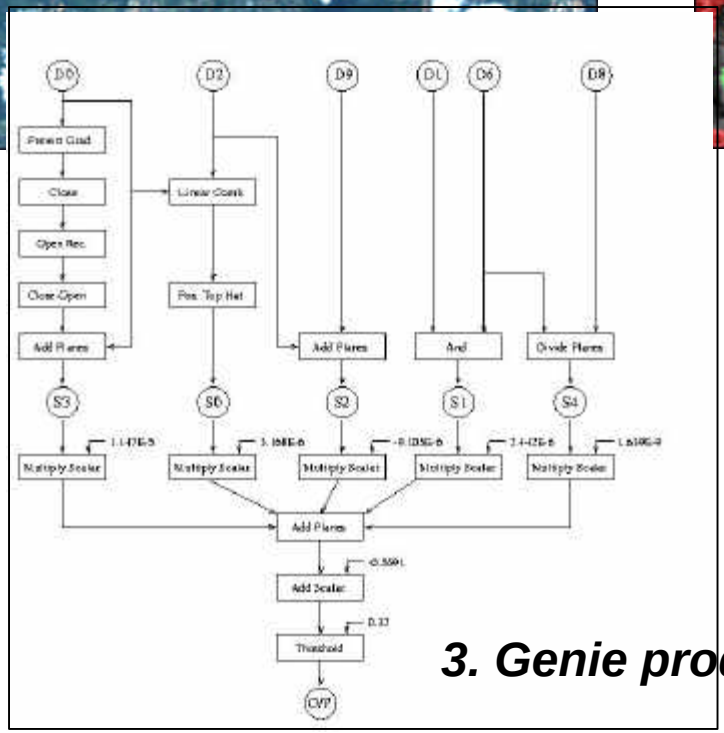


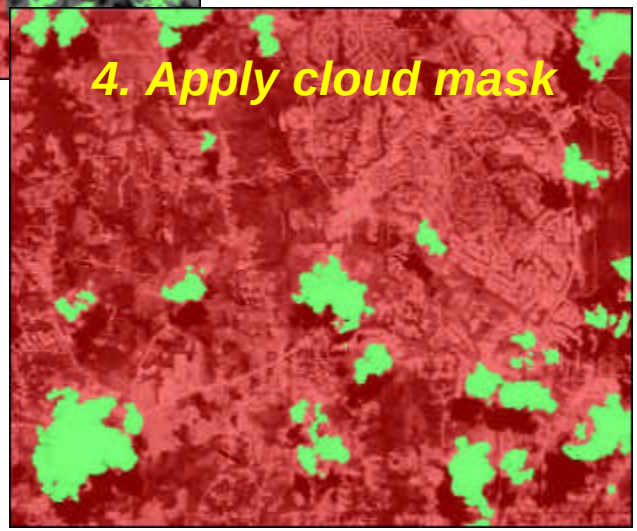
- *MTI (simulated from AVIRIS)*
- *Evolving a crop finder*

Evolving a cloud mask



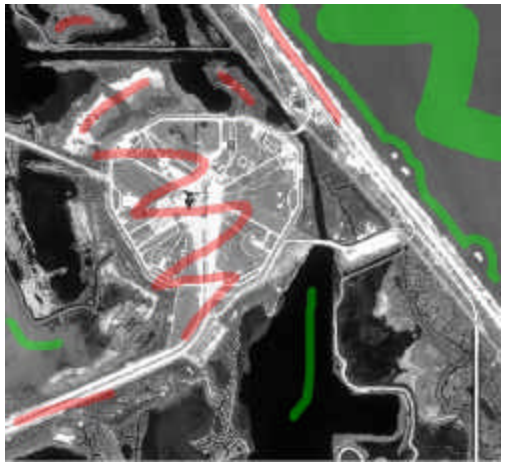




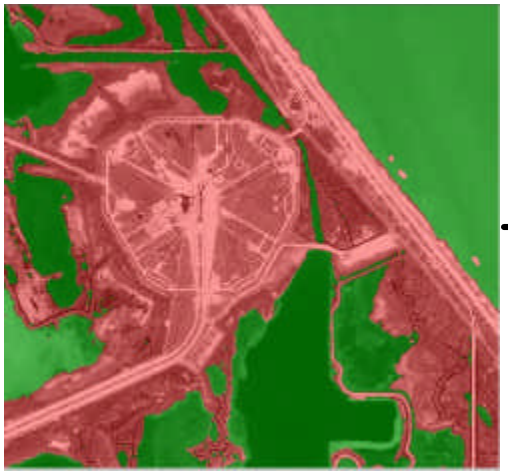


3. Genie produces a cloud mask finder

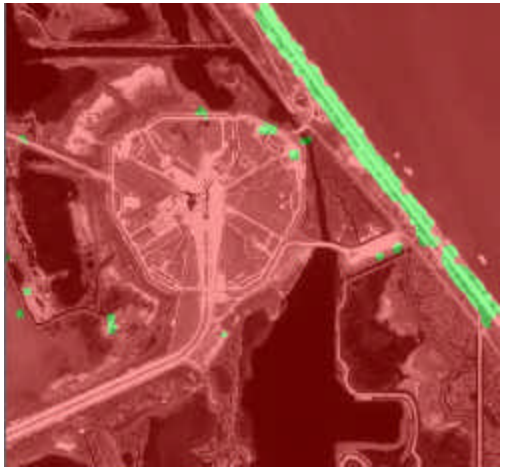
Using water to find the beach



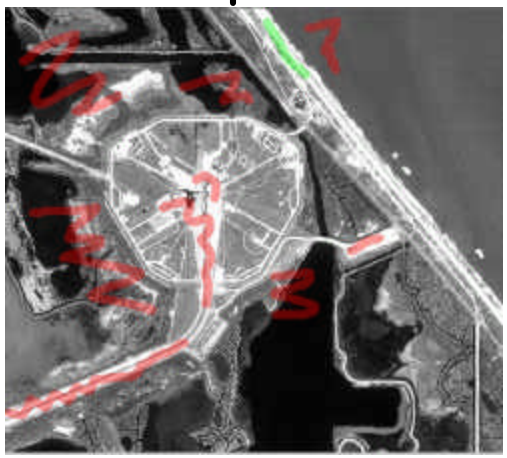
Analyst marks up water



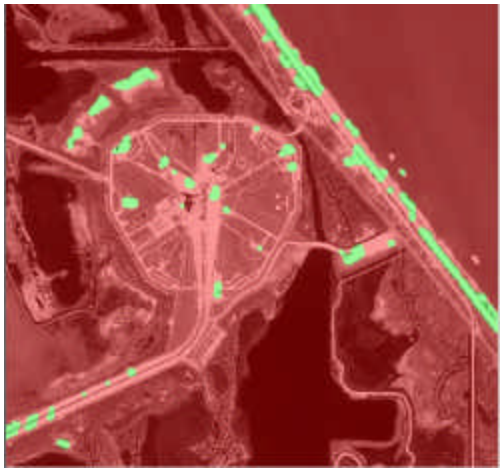
Water mask



Beach mask II
Uses water mask as
a pre-processed plane

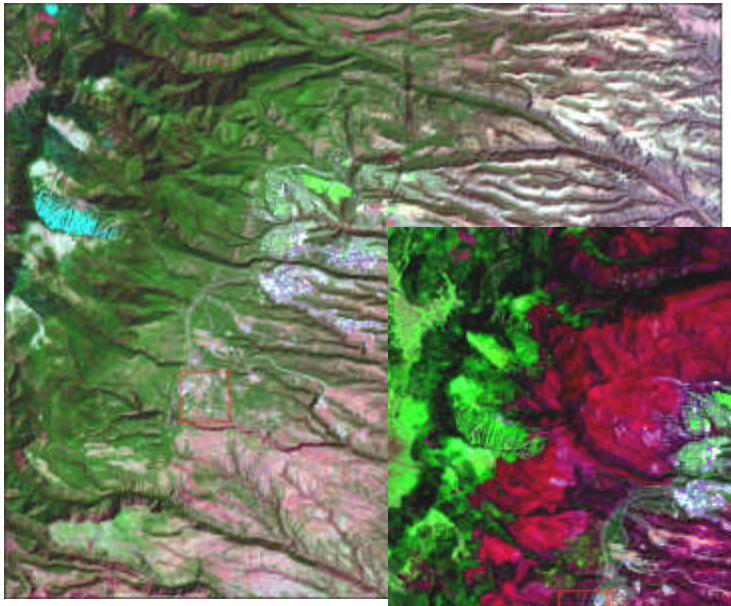


Analyst marks up beach

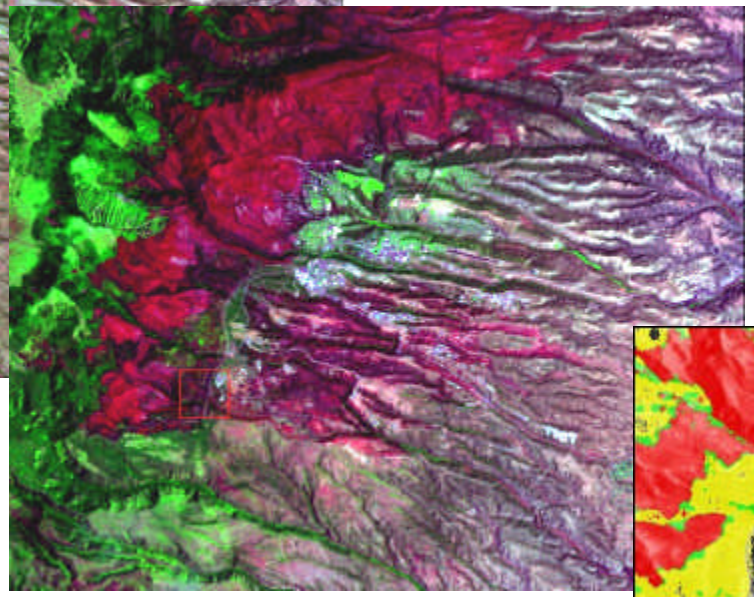


Beach mask I

Cerro Grande Fire: Before and After



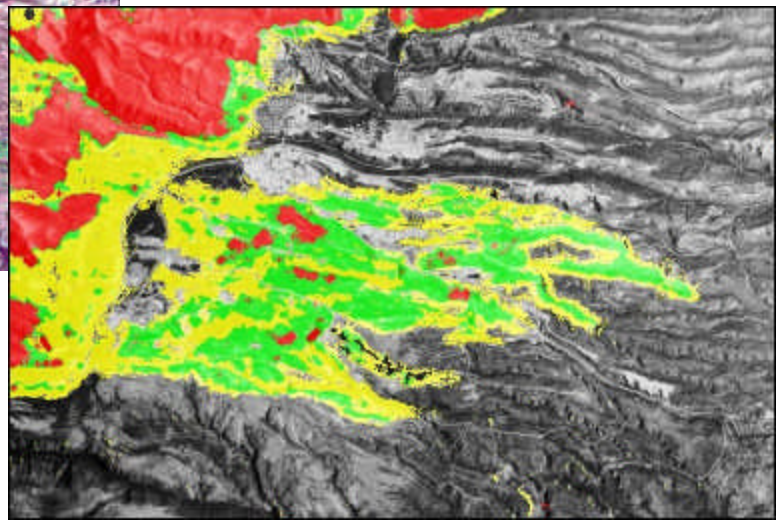
April 14



July 19

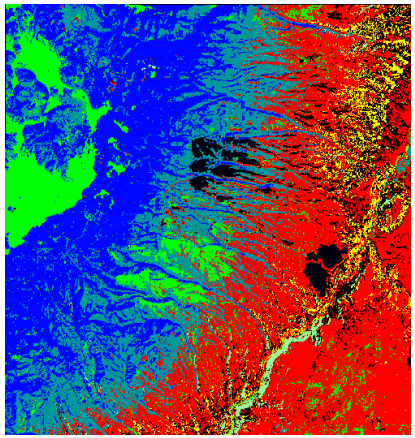
NASA Landsat 7
Multispectral Imagery
Bands 7,4,3

Burn Severity Map
based on Dadaelus MSI
Informed aerial reseeding

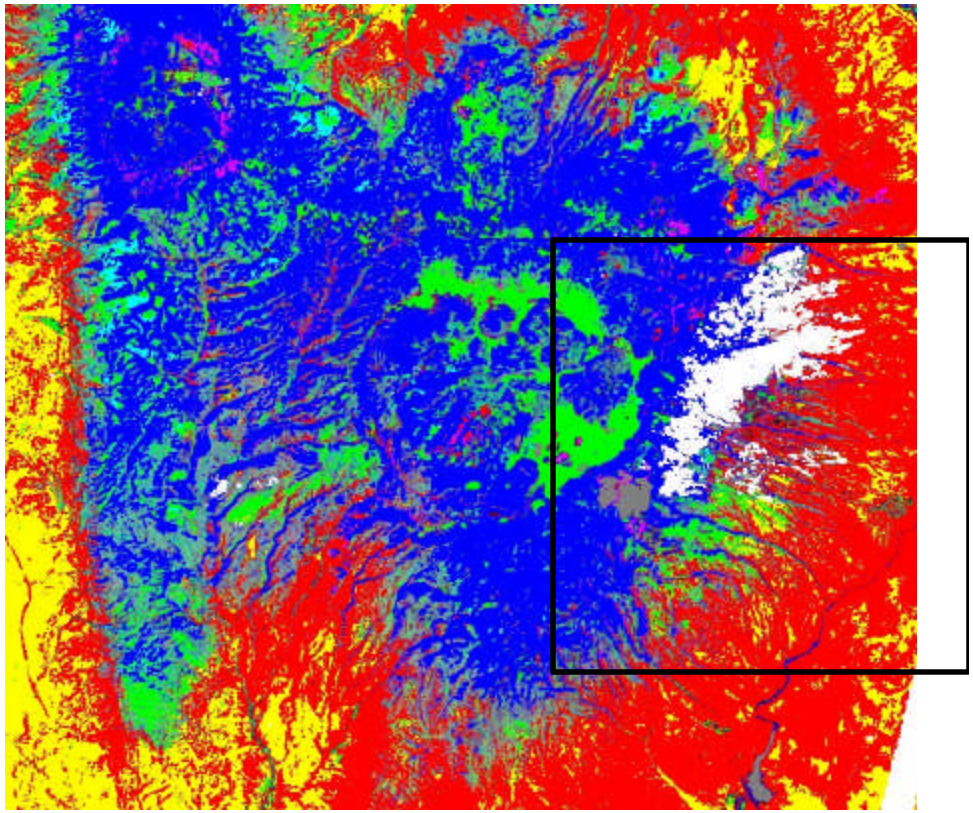


Los Alamos National Laboratory

Land Cover Classification



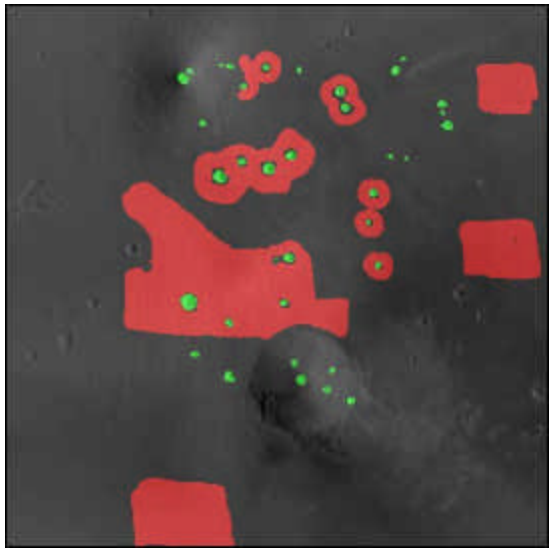
- *"Official" classification map, based on Ground truth from field excursions and Aug 1992, Landsat 5 TM data.*
- *Main Classes*
  - *Red: Pinon/Juniper*
  - *Green: Open grassland*
  - *Blue: Forest*
- *Townsites in black*



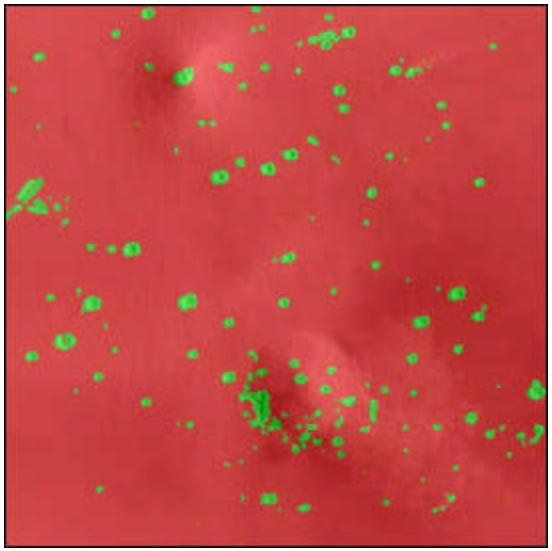
- *Genie classifiation map, based on post-fire, Landsat 7 ETM+ data*
- *Trained four classes*
  - *Red, Green, Blue: from official*
  - *White: Fire damage*
- *Covers much larger region*
- *Needed for Elk Habitat Study*

Training GENIE to find Craters on Mars

Mars Global Surveyor

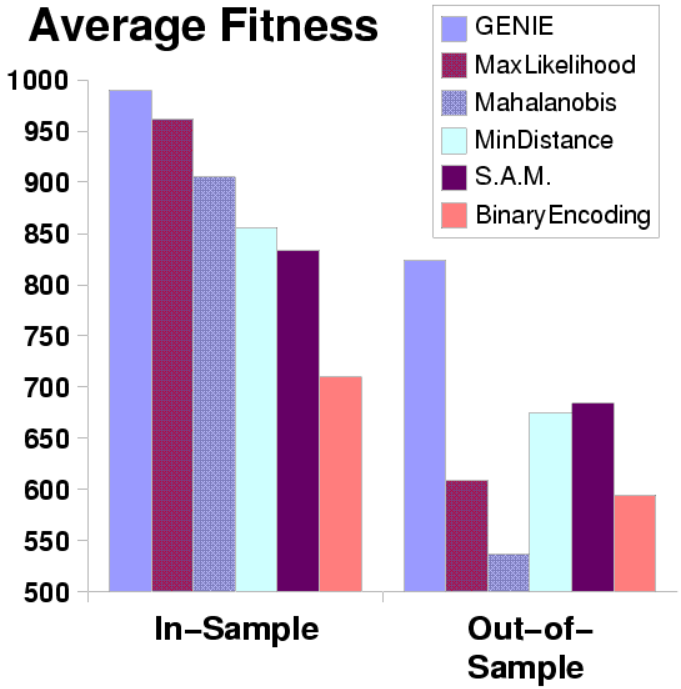


Mars Orbital Camera
Two channel (Red/Blue)
100m resolution



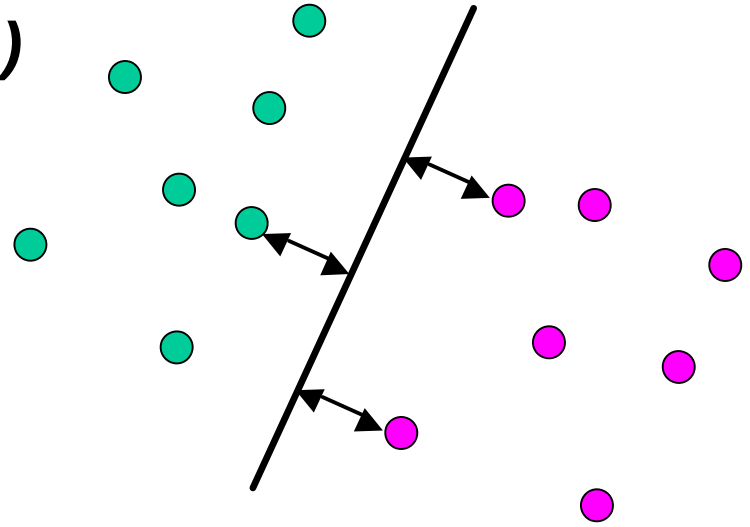
GENIE vs Traditional Classifiers

- Classifiers Implemented in ENVI
  - Maximum Likelihood
  - Mahalanobis distance
  - Minimum distance
  - Spectral Angle Mapper
  - Binary Encoding
- Spectral vs Spatio-spectral
- One class vs Two class
  - true vs background
  - true vs false
- In-sample vs Out-of-sample
  - one set for training, two for testing
- Features: Roads, Clouds, Urban, Golf Courses
- Training time not shown...



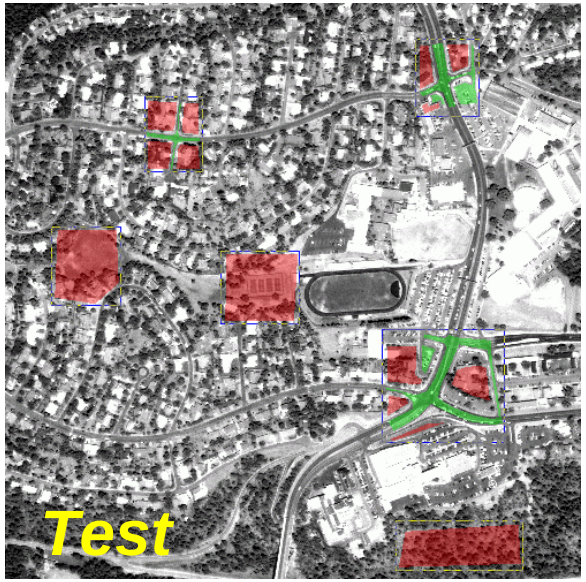
Need for faster machine learning

- *Support Vector Machines (SVM's)*
  - *Vapnik et al.*
- *Empirically very successful*
- *Can learn highly non-linear classifiers, but approach is to transform problem into one of linear separation.*
- *Mathematically well-founded*
  - *Maximizing the "margin" prevents overfitting*
  - *Avoids the "curse of dimensionality"*

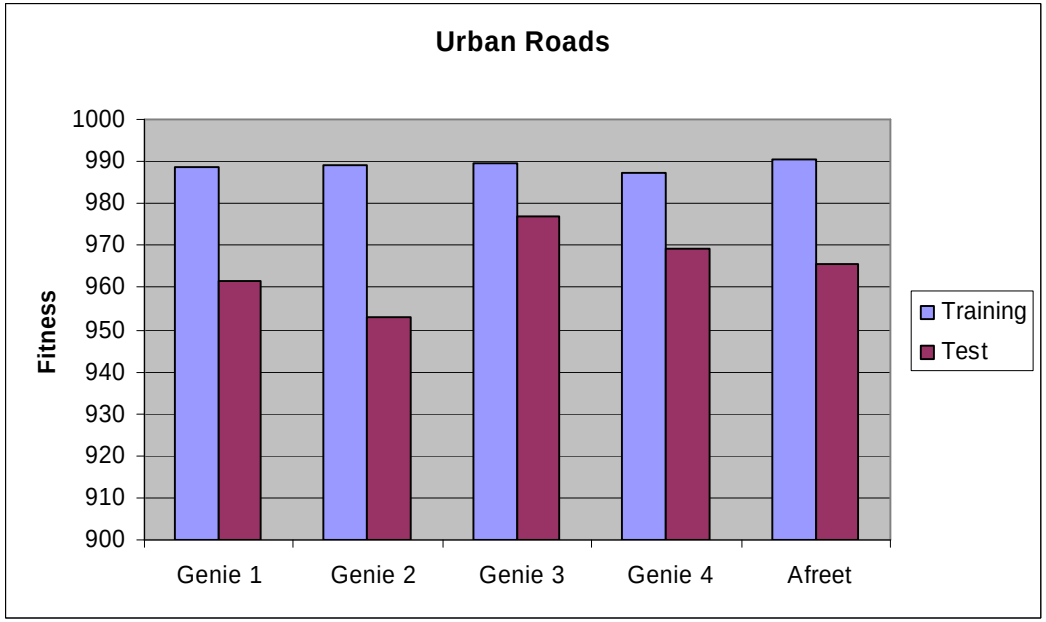


- *Afreet*
  - *implements SVM's for multispectral imagery*

Genie vs Afreet: Urban Roads



- *Aladdin provides training and test data*
- *Genie runs took ~10 hours of compute time each*
  - *2000 evaluations (stopping condition arbitrary)*
- *Afreet training takes ~40 seconds*
  - *but sometimes longer…*
  - *auxiliary spatial planes must be supplied*
- *Afreet II*
  - *automatic feature selection*



GENIE in Hardware

Configurable Pipeline for Feature Extraction

Pipeline Complexity

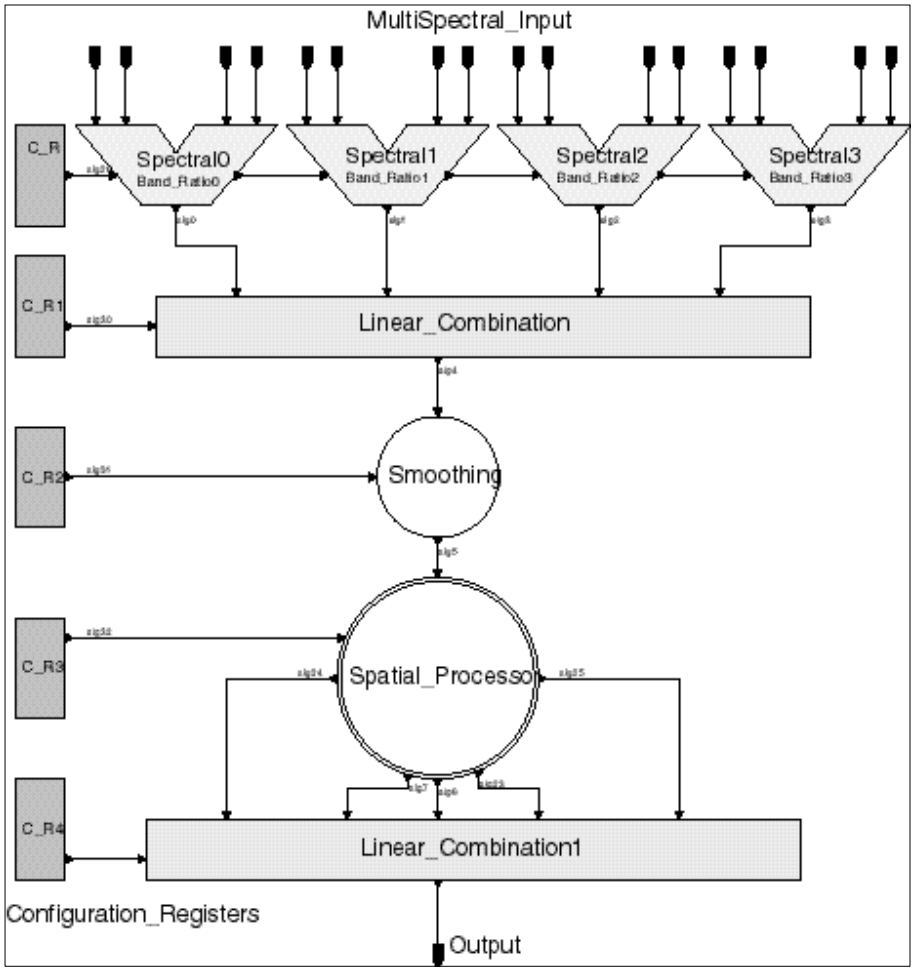
4 Band Ratios
Linear Combination
5x5 Spatial Smoothing
9x9 Spatial Statistics/Morphology
Linear Combination
Threshold (at 0)
Distance calculation to training data

Run-Time Reconfiguration

Four 32 bit on-chip registers store pipeline configuration
~ 6us to program (Wildcard PCMCIA)

Pipeline Evaluation Time

~2.3 ms at 30MHz for 256x256 images



Hardware Genie: Road Finder Result

Results for 2 test images (IKONOS)


- ***Hardware Simulation***
  - ***Training time: ~ 85 seconds***
  - ***Training score: 956/1000***
  - ***Testing score: 960/1000***


- ***Software Experiment***
  - ***Training time: > 6 hours***
  - ***Training score: 954/1000***
  - ***Testing score: 954/1000***